Global Dimming and Brightening: an Update Beyond 2000

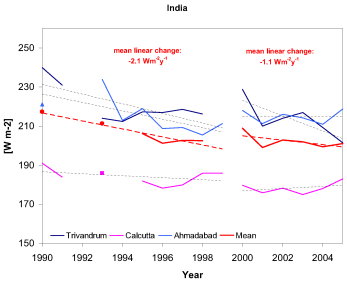
Research Highlight

There is increasing evidence that solar radiation at the Earth's surface has not been constant over time, but has undergone climatologically significant decadal variations. This is indicated, for example, in indirect data from sunshine duration recorders, which show substantial decadal changes since their initiation in the late 19th century.

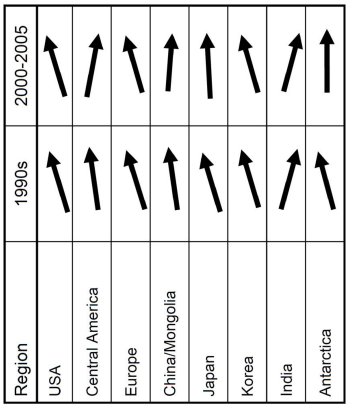
Direct surface radiation measurements started to become available on a widespread basis in the late 1950s, with the establishment of numerous radiation sites during the International Geophysical Year (IGY) 1957/58. Based on these records, several studies pointed to a widespread decrease of surface solar radiation from the early 1960s to the late 1980s ("global dimming"). Only data prior to 1990 were available at the time these studies were completed. More recent studies used data records updated for the 1990s and show that the decline in surface solar radiation faded during the 1980s and, to a large extent, reversed during the 1990s ("brightening"). The present study investigates how surface solar radiation further evolved into the new millennium, based on newly updated surface observational records. The years after 2000 are particularly interesting, because they can provide independent and complementary information to the ambitious satellite programs that became operational with the beginning of the new millennium such as Clouds and the Earth's Radiant Energy System (CERES) and Geostationary Earth Radiation Budget (GERB).

This study investigates recent variations in downwelling surface solar radiation inferred from a comprehensive set of ground-based observational records updated for the period 2000-2005. The surface records suggest a continuation of the upward tendency in surface solar radiation ("brightening") beyond 2000 at numerous stations in Europe and the United States, as well as parts of East Asia (Korea). Insolation variations in Europe after 2000 are dominated by a large positive anomaly in the year 2003 with its unprecedented summer heatwave, exceeding 10 Wm-2 on an annual and 20 Wm-2 on a summer mean basis in Central Europe. However, the brightening in Europe still remains evident, even after eliminating the year 2003 data. The brightening seen at sites in Antarctica during the 1990s, influenced by a recovery from the decreased atmospheric transparency after the Mount Pinatubo volcanic eruption in 1991, fades after 2000. The brightening tendency also seems to level off at sites in Japan. In China there is some indication for a renewed dimming, after the stabilization in the 1990s. A continuation of the long lasting dimming is also noted at the sites in India. Overall, the available data suggest continuation of the brightening beyond the year 2000 at numerous locations, yet less pronounced and coherent than during the 1990s, with more regions with no clear changes or declines.

The tendencies for an increase in surface solar radiation ("brightening") discussed in earlier studies for the 1990s are sustained at the beginning of the 2000s in several parts of the world, as documented at sites in Europe, the US and Korea. Stations in other regions suggest that the "brightening" levels off after 2000 (sites in Japan, Antarctica), or provide some indications for a reversal back to a dimming (sites in China, Central America). In summary, many sites still continue to observe an increase in surface solar radiation in the years following 2000, but the overall signal is not as evident and coherent as during the 1990s, with more sites showing stabilizing or even declining insolation. One may also speculate that the recent decrease in some areas of significant overall brightening may favor a more moderate temperature increase in the early 2000s compared to the 1990s, when brightening more substantially added to the greenhouse-induced warming. Overall global warming since the turn of the millennium may therefore be more readily attributable to the enhanced greenhouse effect, and no longer suppressed by surface solar dimming as in the period from the



Evolution of annual mean surface solar radiation from 1990 to 2005 as measured at sites in India showing continued significant dimming. The updated focal period 2000-2005 is visually separated from the preceding 1990-2000 period. Units Wm-2.



Qualitative tendencies in surface solar radiation at sites in various regions around the world. 1990s tendencies in left column, 2000-2005 tendencies in right column.

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1950s to 1980s or as enhanced by surface solar brightening as from the 1980s to 2000.

Reference(s)

Wild M, B Trüssel, A Ohmura, CN Long, G König-Langlo, EG Dutton, and A Tsvetkov. 2009. "Global dimming and brightening: An update beyond 2000." Journal of Geophysical Research – Atmospheres, 114, D00D13, 10.1029/2008JD011382.

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Radiative Processes